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SHORT COMMUNICATION

Information service platform of forest pest forecast based on WebGIS

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Abstract: Taking Linkou Forestry Bureau, Heilongjiang Province, China as the demonstration plot and *Dendrolimus pinidiatrea* as an example, we developed a WebGIS-based information service platform for forest pest forecast using J2EE and ArcGIS Server technology. The service platform is able to predict the occurrence period, amount of pest, occurrence tendency, and pest zones in the B/S environment and realized the display, querying, analysis and editing of the spatial data and the automatically integrated control of multilevel Data,. Additionaly, the service platform offers the visualization of geographic service and predicted results. It provides a solution for prediction of forest pest and forest resource management.

Keywords: WebGIS; Information service platform; pest forecast; forest pest; ArcGIS Server

Introduction

Geographical Information System (GIS) is a collection of computer hardware, software, and geographic data for capturing, managing, analyzing, and displaying all forms of geographically referenced information (DeMers 2001). With the GIS technology, we can obtain spatial information easily, and represent and process the data effiently. The GIS has been widely used in forest insect control, forest fire prevention and forest resources management. With the development of the Internet and present-day information techniques, WebGIS can further develop the GIS functionality in the Internet. With WebGIS, the user can work with maps and databases on web without buying and installing expensive GIS software. Xu et al. (2008) established a diseases and insect pest information system based on WebGIS and propsoed a general interface standard for WebGIS. They discussed the design principle and realizaion approach for the intelligent decision-making inference module in the system, but did not use WebGIS to show the occurrence tendency of the insect and disease. A WebGIS-based fire position system was established by Gao et al (2004) on GeoMedia Web Map, not on ArcGIS Server. Besides the application in forest disease and forest fire prevention, WebGIS is also used in forest resources management. Wang et al. (2007) discussed the application of forest resources management information system based on J2EE architecture and ArcGIS Server, and Wu et al. (2003) set up a forest resources management information system based on WebGIS. With the forest resources management information system, forestry administrative departments can strengthen the interdepartmental communication, realize data sharing, improve official business efficiency, optimize management means, and make scientific decisions.

In the present study, we took Pine-moth (*Dendrolimus pinidiatrea*) as an example to establish the Web-based Forecast Expert System for Forest Diseases and Insects. The whole system is consisted of two modules, the expert system and WebGIS platform. The expert system mainly provides information on prevention and control of forest disease and insect. Its system architecture, including the design of the inference engine and knowledge base, was discussed in the previous published paper (Wang et al.2008). This paper illustrates the implementation of GIS in pest expert system, which integrates J2EE with ArcGIS Server technique, and focuses on the implementation of WebGIS Information Service Platform in the total system and the prediction of occurrence quantity.

Technical description

J2EE description

J2EE (Java 2 Platform Enterprise Edition) is a plat-

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form-independent, Java-centric environment from Sun company for developing, building and deploying Web-based enterprise applications online. The J2EE platform consists of a set of services, APIs, and protocols that provide the functionality for developing multitiered, Web-based applications. J2EE include Java Server Face (JSF), Java Server Pages (JSP), JavaServlet, EJB, and so on. These techniques consist of the high performance and expandable J2EE framework (Keogh. 2002).

Java Server Faces (JSF) is a new standard Java framework for building Web applications with server-side user interface functionality. It simplifies Java Web application development by handling all of the complexities associated with managing a user interface (Dudney et al. 2004). JSF ensures that applications are well designed with greater maintainability by integrating the well established Model-View-Controller (MVC) design pattern into its architecture. The view is the presentation layer, which is responsible for interaction with the user. The model is the business logic and data, and the controller is the application code that responds to user events and integrates the model and view. This architecture ensures that the application is loosely coupled, which reduces dependencies between different layers (Fig. 1).

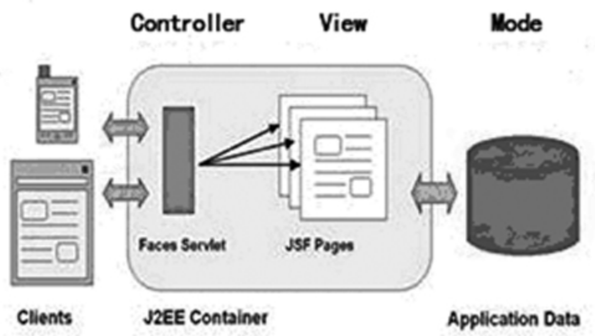


Fig. 1 JSF architecture based on MVC

ArcGIS Server description

ArcGIS Server is a distributed system, which consists of several components that can be installed across multiple machines. Each of the components in the ArcGIS Server system plays a specific role in the process of managing, activating, deactivating, and load-balancing the resources that are allocated to a given server object or set of server objects.

The ArcGIS Server consists of two parts: a GIS server and an Application Developer Framework (ADF) for .NET and Java (ESRI. 2004). The GIS server hosts ArcObjects for use by Web and desktop applications. It includes the core ArcObjects library and provides a scalable environment for running ArcObjects in the server. The ADF allows you to build and deploy .NET or Java desktop and Web applications that use ArcObjects running within the GIS server. And it includes a software developer kit (SDK) with software objects, Web controls, Web application and so on. This GIS is the expansion and application of Web controls based on ADF. The Java ADF Web controls are built with the JSF that integrate GIS functionality into web application.

System framework design

System's global schema associates J2EE with ArcGIS Server, and build up WebGIS system with multilayer architecture. It fully stands for maintainability, safeness, expansibility in modern Information Service Platform. For WebGIS Platform we designed, we divided the system into four tiers: Client Tier, Web Tier, Business Tier and Database Tier, according to J2EE enterprise-standard. Client Tiers are used to connect to web applications running in the web server, usually IE-browsers or other applications. They generally follows the HTTP protocol. The users can finish the operation through the Internet. Web Tier is consisted of JSF and JSP.

Business Tirer is consisted of the GIS SERVER and the WEB SERVER. GIS Server hosts and runs server objects. The GIS server consists of a server object manager (SOM) and one or more server object containers (SOCs). The GIS Server can be considered as equivalent to SOM and several SOCs; that is, GIS Server=SOM+ n*SOC (Wu et al.2006). The SOM handles web application assignment when the users pose requests, and then provides for the connection to the SOCs to be made. The SOCs host the SOs that are managed by SOM. If multilayer architecture is used, the number of the users will be larger according to the developing of the system. In this case, we can use more machines standing for SOCs to make system load balancing and to keep on the speed of system response. As the SOs are running on the SOCs and these SOs are balanced equally across all the SOCs, the SOCs also should be load balancing (the same CPU, the same RAM).

Database Tier uses Oracle is to store all the data and uses ArcSDE (spatial data engine) as the connection of Oracle to hold spatial data and property data (ESRI. 2002). SDE hosts geographic characteristic information and property information gathered in relational database and makes use of the strong executive ability of database to hold the spatial data and property data. It enables the accession to the spatial data form database faster and also ensures the consistency of spatial data between property data and data integrality.

System implementation

According to the requirement of the users, WebGIS Platform has been divided into six program modules as Basic operation, Forest sub-compartment map, Permanent sample plot management, Pest forecasting, forest disease and insect control stations, and Map editing.

Basic operation

zoom in: the system will show the enlarging map; *zoom out*: the opposite operation of the zoom in operation; *full extent*: to see the full scene of the map; *identify*: select property information from the map; *distance measuring*: get the distance between two points or several points (the line between these points must be

straight lines); *fuzzy query*: search for and find features on the map, and then these features will change colors; *printing*, print the map in different resolutions; *point location*: find a point after inputting the GPS coordinate. The user can interactively toggle layers on and off to show different layers on the map.

Forest sub-compartment map

This module is for the user to render features with thematic methods, such as elevation distribution, dominant tree species, growing stock of sub-compartment and so on. The user can get different thematic mapping capabilities on the map by interactively toggling layers on and off.

Permanent sample plot management

This module is used to manage the permanent sample plots. The user can create a new permanent sample plot and their attributes, and can also delete some of them.

Pest forecasting

This program module includes predictions of the pest occurrence period, infecting quantity, pest occurrence trend, and infected area.

Currently, two methods, effective cardinality and mathematics statistics, are commonly used to compute the insect density for *Dendrolimus pinidiatrea.* Effective cardinality is calculated by the following equation

$$P = P_0 \times e \times \left[f / \left(m + f \right) \right] \times \left(1 - M \right) \tag{1}$$

Where, P is the occurrence quantity of the next generation, P_0 is the insect density of this generation, e is the number of lay eggs of this generation, f is the number of male, and M is the mortality rate in different intars.

Mathematics statistics method uses the following equation:

$$P = 9.544 + 0.014X_1 + 0.161X_2 - 0.159X_3 - 0.145X_4 - 0.271X_5 - 0.899X_6 \tag{2}$$

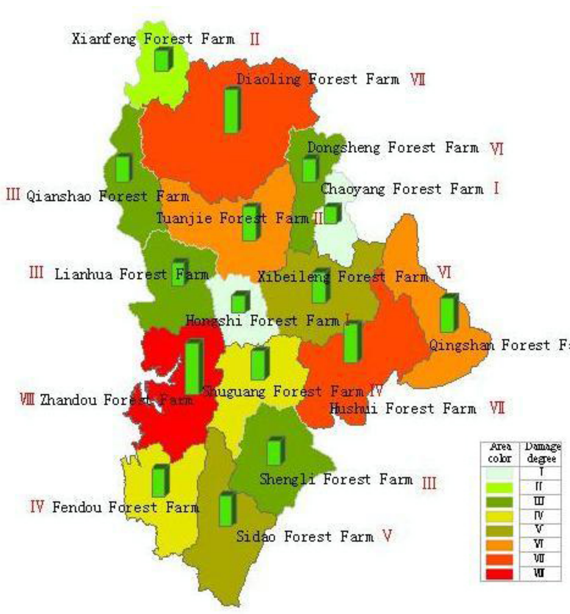
where, P is the occurrence quantity of the next generation, X_1 is the rainfall in August, X_2 is the relative humidity in August, X_3 is the high temperature in January, X_4 is the low temperature in Jan, X_5 is the low temperature in August, and X_6 is the average temperature in July.

Investigation of forest disease and insect pest should be carried out every year. Firstly we divide the insect density into eight degrees, mark with different color, and give weight factor for each degree (see Table 1). On the basis of the parameter data used in eqs. 1 and 2, the Information Service Platform can carry on calculation for the prediction of occurrence quantity and classify the prediction occurrence quantity according to Table 1. With the insect density and corresponding weight factor, the WebGIS-based platform can automatically create prediction map of occurrence quantity of pest The map can show the forecast trend and risk rank for different areas and use histogram to show the insect density.

Table 1. Standard of population density of insect

Insect density	Damage degree	Weight factor
0-5 head/plant	Ⅰ	1
6-10 head/plant	Ⅱ	2
11-15 head/plant	Ⅲ	3
16-20 head/plant	Ⅳ	4
21-30 head/plant	Ⅴ	5
31-40 head/plant	Ⅵ	6
41-65 head/plant	Ⅶ	7
More than 65 head/plant	Ⅷ	8

In this study, we take Linkou Forestry Bureau, Heilongjiang Province, China as an example and used Eq. (2) to predict the occurrence of *Dendrolimus pinidiatrea* (Fig. 2). For example, in 2008, the weather data for Shuguang Forest Farm of Linkou Forestry Bureau are as follows: the rainfall in August is 1700 mm, the relative humidity in Aug 70%, the high temperature in Jan -20°C, the low temperature in August 10°C, and the average temperature in July is 19°C. By the compution, the predicted insect density of *Dendrolimus pinidiatrea* for the year 2009 is 16 head/tree, weight factor is 4, and the damage degree is Ⅳ (Fig. 2).



* Population density of insect is shown as the histogram

Fig. 2 Prediction map of occurrence quantity and occurrence areas of ***Dendrolimus pinidiatrea*** **by WebGIS Platform**

The WebGIS-based platform can also give the predictions of occurrence period, occurrence trend and occurrence areas, and all these results can be saved as the historical data for future use.

FDICS searching

This module can locate forest disease and insect control stations (FDICS) for the user to select the nearest FDICS around the occurrence areras, and aslo can show the optimal path form the station to occurrence area in high bright color in the map.,

Map editing

Map editing module can draw graphic features such as points, lines, circles and polygons, allow the user to add a new FDICS on the map and update its attributes. In addition, this module can also allow the user to divide a loging area into several sub-logging areas; however, at present the system can only divide the graphic features, but not their attributes.

Discussion and conclusion

Information service platform of forest pest prediction is based on J2EE and ArcGIS Server technique, and sets up multi-layered WebGIS system, which is very maintainable and extendable and can conveniently realize reuse and assembly of software components. Therefore, the platform can enhance the maintainability, security and the extension of the system, speed up the development speed and reduce the development risk.

The Map editing module in the system needs improving. The system is requred to update attributes by the same time after the user divides the Graphic features. GPS will be incorperated into the system, so that when the pest and disease occurs, the foresters can use a PDA to find the places and update the attributes.

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